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U1S S1883 S1991

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EP 0735268 A2 EP 0643219 A1
WPI Abstract Accession No. 97-333890/199731 &
DE19548278 A1

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INT CL[6] F02D 41/30 41/32 41/38 , G05D 16/20
Online database: WPI

(54) Abstract Title
Regulating the fuel pressure in an internal combustion engine

(57) Controlling a high-pressure fuel supply installation in an internal combustion engine, in particular an engine with a common fuel rail system 130, comprises the steps of conveying fuel by pumps 110 and 125 from a low-pressure region into the high-pressure region including the rail 130, detecting the fuel pressure P in the rail 130 using a pressure sensor 145, and then setting the pressure to a target value using a regulator. The regulator comprises a control device 160 which acts on the coil 136 of a pressure regulating valve 135. The valve discharges a regulating fuel quantity QDRV from the rail 130 back into the low pressure region in dependence on the control signal A and the coil 136. This regulating quantity is itself regulated to a target value - thus the fuel pressure and the regulating quantity can be set independently of each other. The control device 160 processes signals from various sensors 165, 166 representing operational states of the engine, such as rotational speed and temperature.

FIG. 1

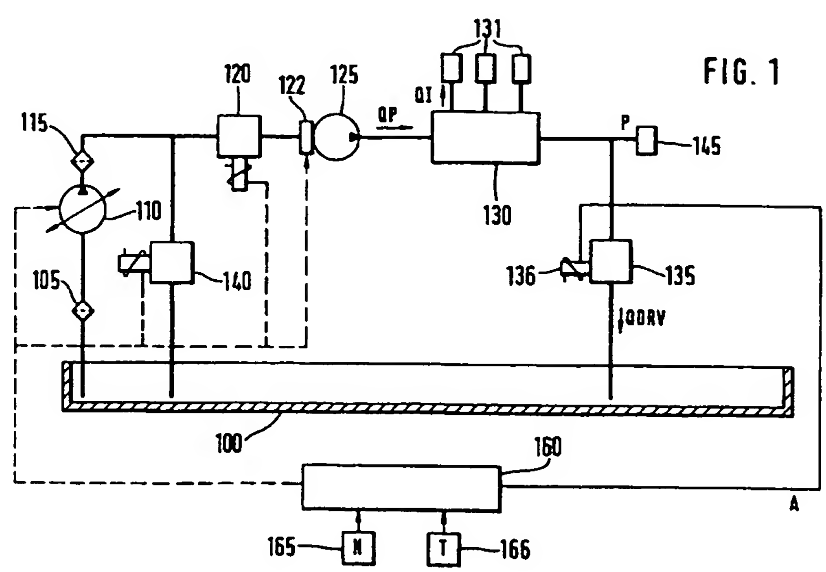

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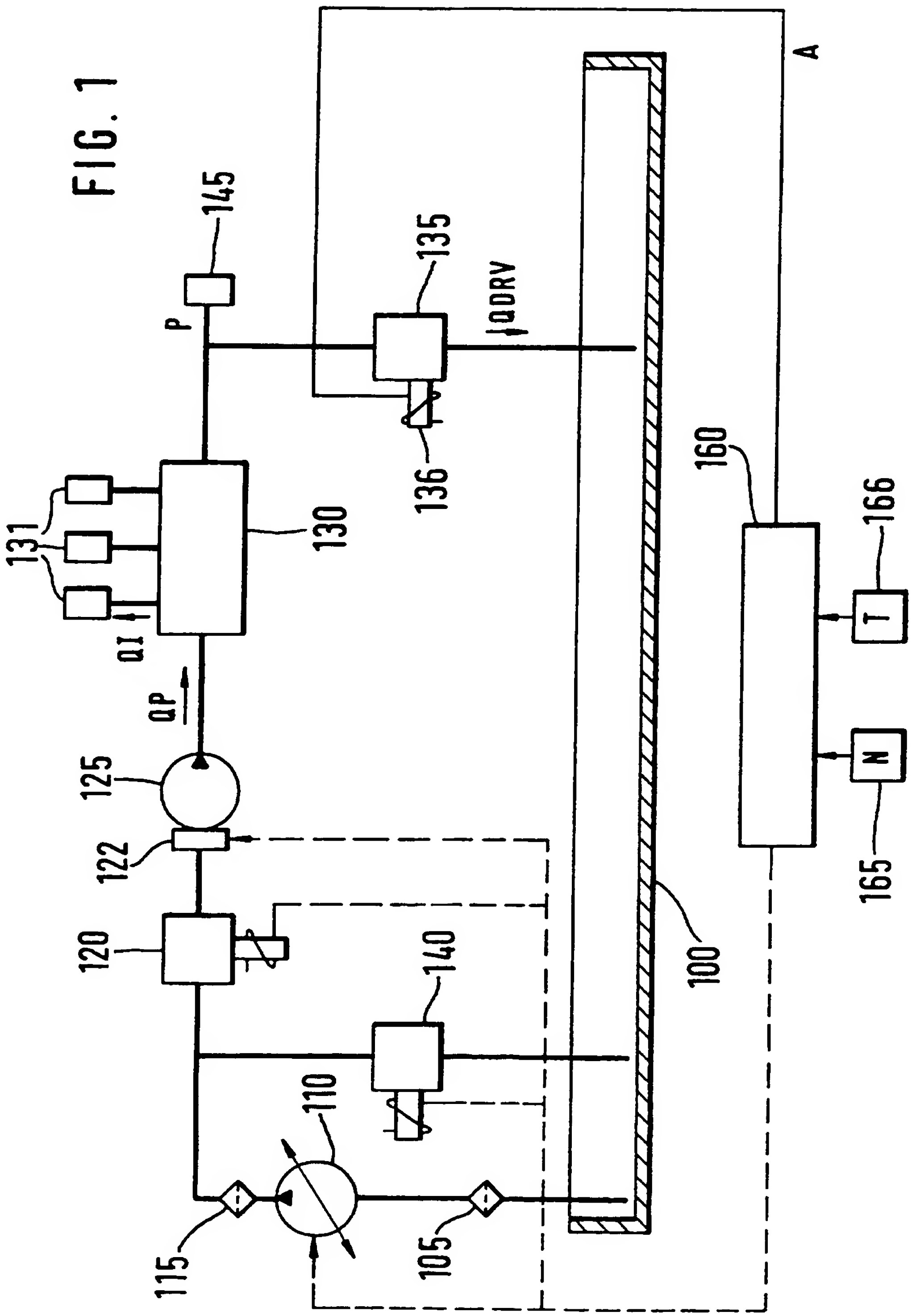
FIG. 1


100
105
110
115
120
122
125
130
131
135
136
140
145
160
165
166
A
P
QP
QI
QDRV
T
N

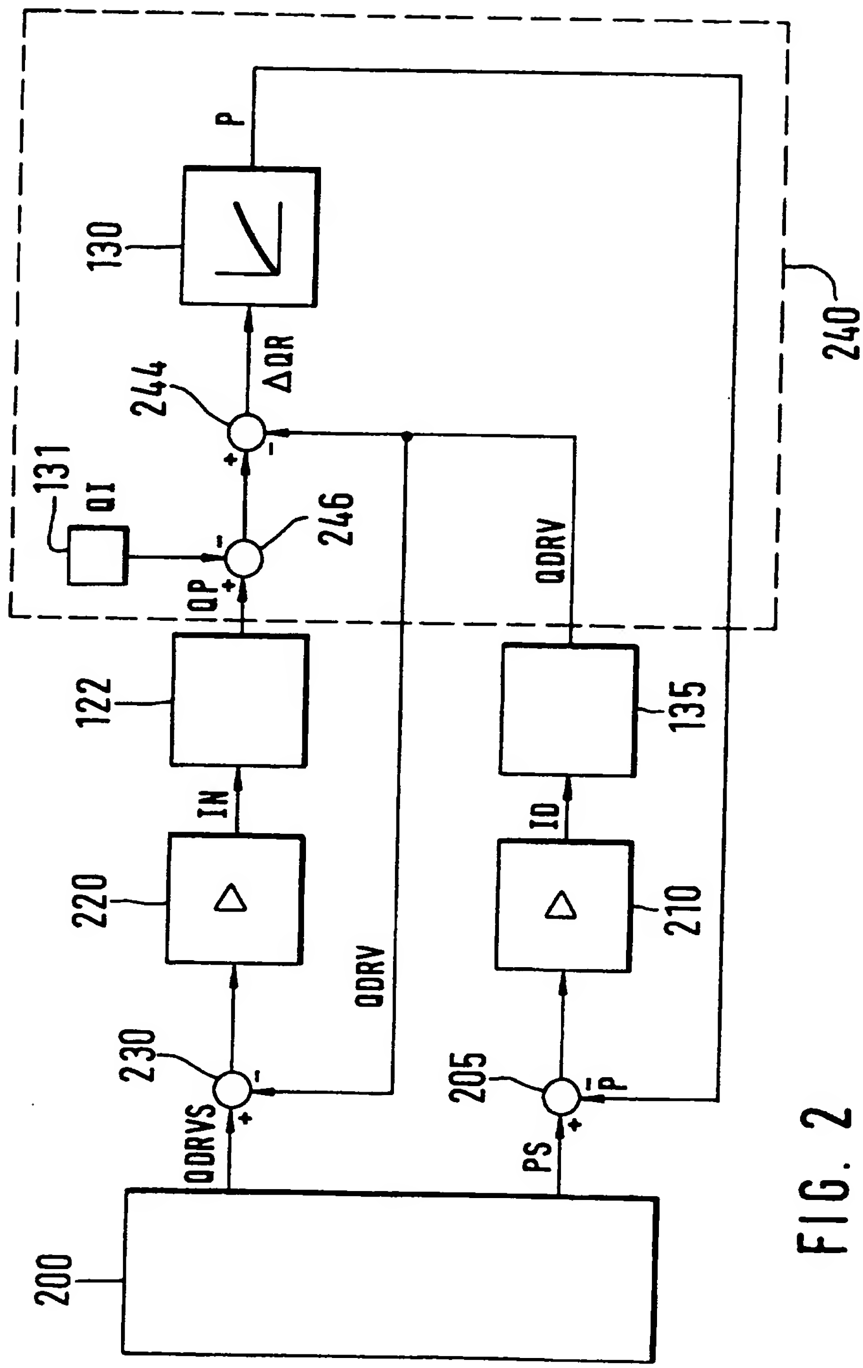
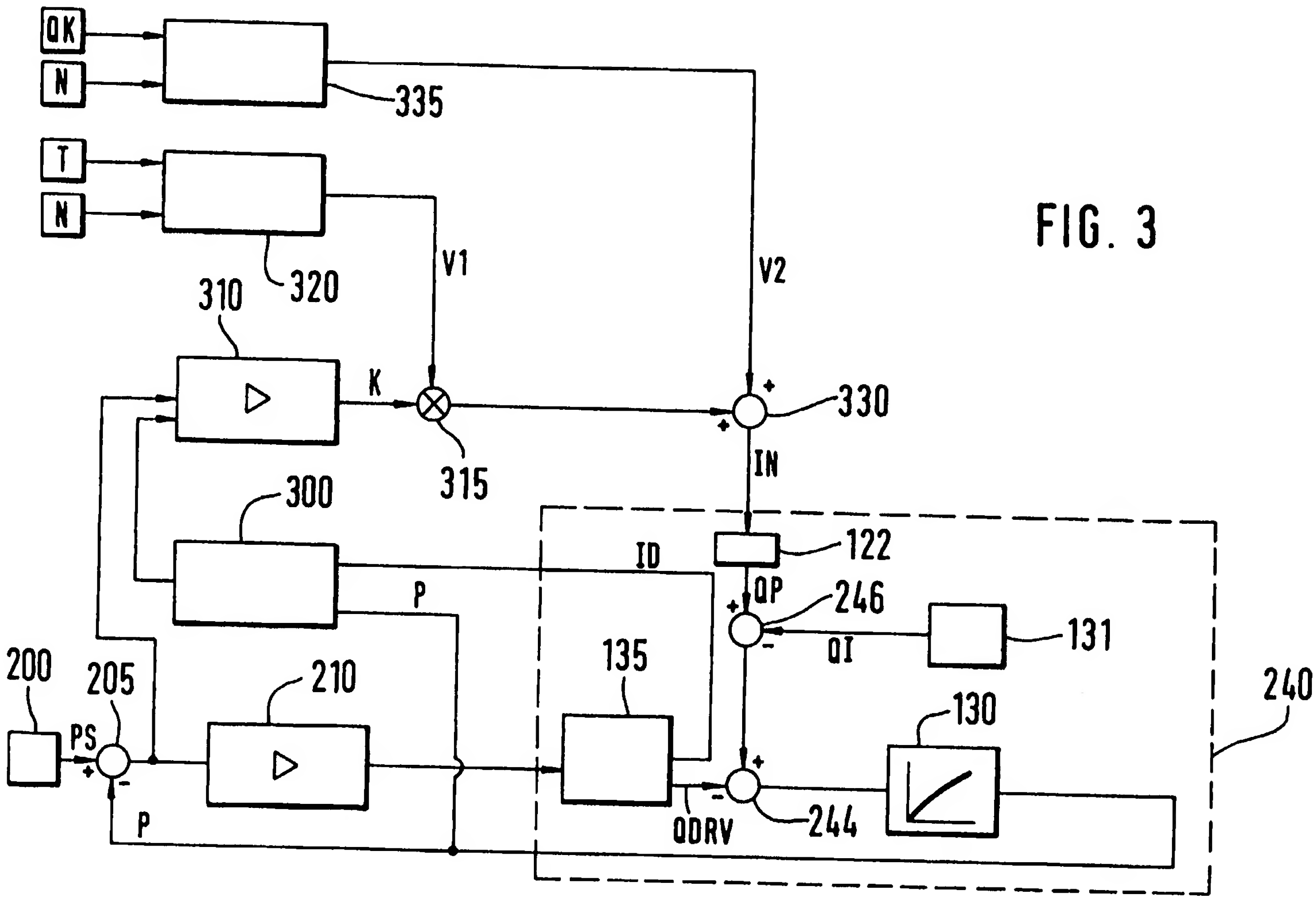

200
QDRVS
PS
230
205
QDRV
220
210
IN
ID
122
135
QP
QI
131
246
244
QDRV
ΔQR
130
P
240

FIG. 2

FIG. 3


QK
N
335
T
N
320
V1
V2
310
K
315
330
IN
300
ID
122
P
QP
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200
205
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135
240
130
PS
P
QDRV
244

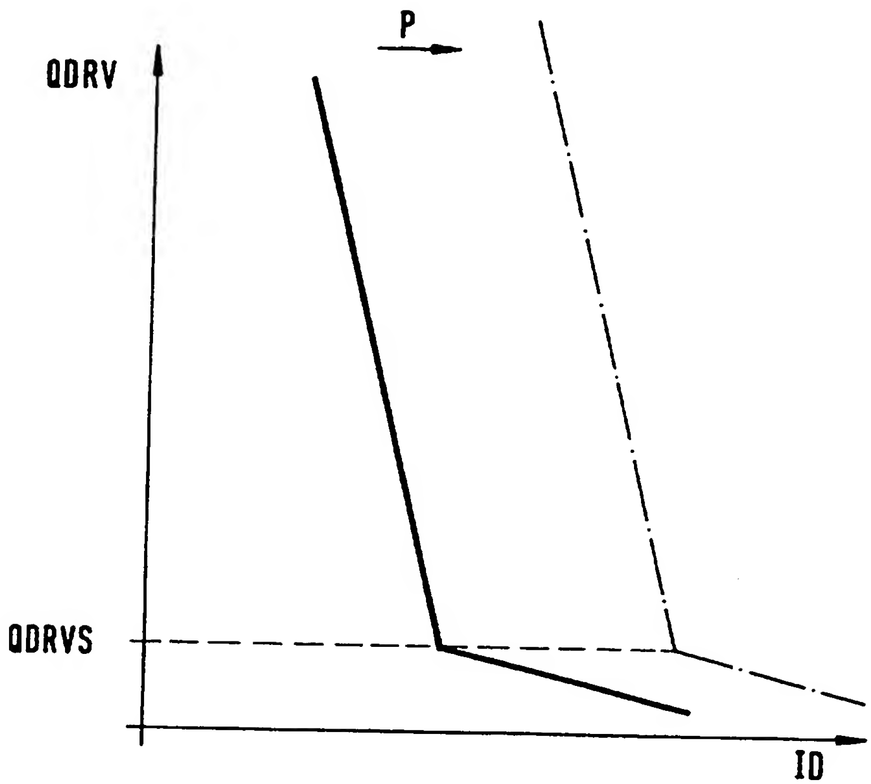

FIG. 4

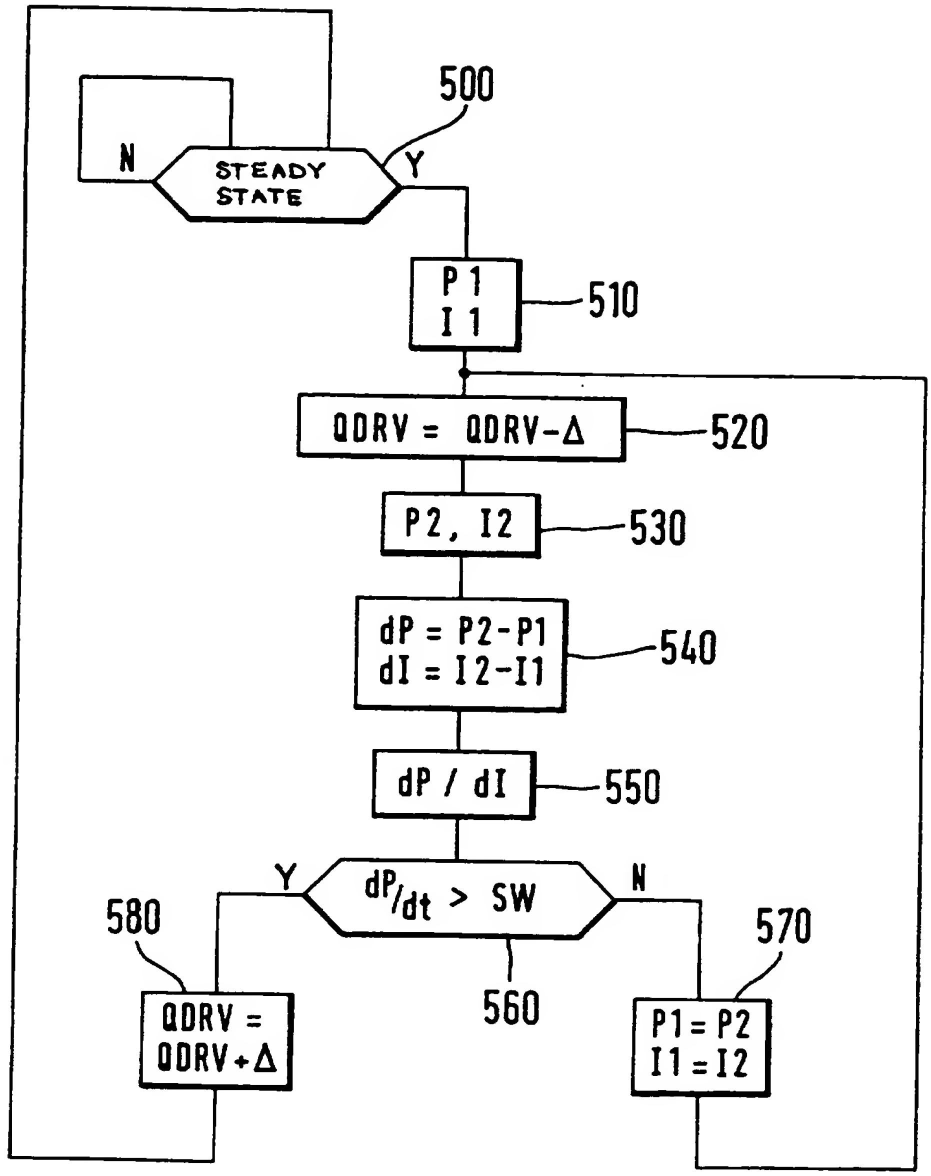
500
N
STEADY STATE
Y
P1
I1
510
QDRV = QDRV-Δ
520
P2, I2
530
dP = P2-P1
dI = I2-I1
540
dP / dI
550
Y
dP/dt > SW
N
580
560
570
QDRV = QDRV+Δ
P1 = P2
I1 = I2

FIG. 5

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METHOD OF AND CONTROL MEANS FOR CONTROLLING AN INTERNAL COMBUSTION ENGINE

The present invention relates to a method of and control means for controlling of an internal combustion engine.

A method and a device for the control of an internal combustion engine are described in DE 195 48 278, in which the method and device serve for regulation of the pressure in a storage device in the form of a common fuel rail system. For regulation of the pressure, a regulating quantity is discharged from the storage device into a low-pressure region, in which a second regulator acts. A pressure-regulating valve, which regulates the pressure in the storage device, operates in an unstable manner in the case small regulating quantities. On the other hand, large regulating quantities are undesired, since the high-pressure pump then conveys fuel unnecessarily. This unnecessary conveying leads to heating of the fuel and a reduction in the performance of the engine, which in turn has the consequence of an increase in fuel consumption. However, in certain operational states when the pressure is to be reduced rapidly to a lower target value, a large regulating quantity is desired so that a rapid pressure decay takes place.

It would thus be desirable to achieve a stable and exact regulation of fuel pressure in a fuel storage device of an engine fuel supply system, so that a heating of the fuel is avoided or the energy consumption in the setting of the pressure is reduced.

According to a first aspect of the invention there is provided a method for the control of an internal combustion engine, especially an engine with a common fuel rail system, wherein at least one pump conveys fuel from a low-pressure region into storage means and the pressure in the storage device is detectable, and a pressure-regulating means discharges a regulating quantity of fuel from the storage means into the low-pressure region for setting the pressure in the storage means, characterised in that the regulating quantity is regulable to a target value.

Preferably, a first regulator regulates the pressure in the storage means and a second regulator regulates the regulating quantity. Expediently, the first regulator acts on pressure-regulating means starting from a target value and an actual value for the

pressure. The second regulator can act on a setting element which is arranged in the low-pressure region and/or act on a high-pressure pump.

For preference, the second regulator controls the setting element starting from at least a change in current flowing through the pressure-regulating means and change in the pressure in the storage means. Alternatively or additionally, the second regulator can control the setting element starting from at least the difference between the actual value and the target value for the pressure.

Preferably, the setting element is controllable in drive by at least one preliminary control and the second regulator corrects the preliminary control values. The preliminary control can control the setting element in dependence on different operating parameter magnitudes, such as quantity of fuel to be injected and/or rotational speed.

According to a second aspect of the invention there is provided control means for the control of an internal combustion engine, especially an engine with a common fuel rail system, wherein at least one pump conveys fuel from a low-pressure region into storage means and the pressure in the storage means is detectable, and a pressure-regulating means discharges a regulating quantity from the storage means into the low-pressure region for setting the pressure in the storage means, characterised in that means are provided to regulate the regulating quantity to a target value.

The two important magnitudes of fuel pressure and regulating quantity can thus be set independently of each other. The fuel pressure can be set rapidly to desired values in dependence on the operational states. The regulating quantity can be kept very small. In the case of a rapid pressure decay, however, the regulating quantity can be rapidly set to a high value.

An example of the method and embodiment of the control means of the present invention will now be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a control device embodying the invention;

Fig. 2 is a block circuit diagram of regulating means in the device;

Fig. 3 is a block circuit diagram of modified regulating means in the device;

Fig. 4 is a diagram showing the relationship of a fuel quantity and drive control current in operation of the device; and

Fig. 5 is a flow chart illustrating steps in a method exemplifying the invention.

Referring now to the drawings there is shown in Fig. 1 part of a fuel supply system of an internal combustion engine with high-pressure injection, the illustrated system usually being termed a common rail system.

The system comprises a fuel supply container 100, which is connected by way of a first filter 105 and a preferably controllable preliminary conveying pump 110 with a second filter 115. Fuel passes from the second filter 115 by way of a duct to a valve 120. The connecting duct between the filter means 115 and the valve 120 is connected with the container 100 by way of a low-pressure limiting valve 140. The valve 120 is connected with a high-pressure pump 125 by way of an admetering unit 122. The admetering unit 122 is arranged at the suction side of the high-pressure pump 125. A magnetically controlled proportional valve can be used as admetering unit.

The high-pressure pump 125 is connected with a common fuel rail 130, which also represents a storage device and is connected with injectors 131 by way of fuel ducts. The rail 130 is also connected with the container 100 by way of a pressure-regulating valve 135 controllable by means of a coil 136.

The ducts between the exit of the high-pressure pump 125 and the entry of the pressure-regulating valve 135 represent a high-pressure region. In this region, the fuel is under high pressure. The pressure P in the high-pressure region, in particular in the storage device, is detected by means of a sensor 145. The ducts between the container 100 and the high-pressure pump 125 represent a low-pressure region.

A control unit 160 contains a pressure regulator and acts on the corresponding setting elements, for example the coil 136 of the pressure-regulating valve 135 and/or the admetering unit 122, by drive control signals A. The control 160 processes signals from

different sensors 165 and 166, which characterise the operational state of the engine and/or of a motor vehicle fitted with the engine. Such a signal characterises, for example, the rotational speed N of the engine or a temperature value T.

It is particularly advantageous if the control 160 controls further or other setting elements in drive. For regulation of the pressure P in the high-pressure region, further setting elements can be used alternatively and/or additionally. Such a further setting element is, for example, an electrical preliminary conveying pump adjustable in respect of conveyed quantity, a controllable high-pressure pump and/or a pressure-regulating valve 140 in the low-pressure region.

In use, fuel in the container 100 is conveyed by the pump 110 through the filters 105 and 115. At the exit side of the pump 110, the fuel is acted on by a pressure of a few bar. When the pressure in the low-pressure region of the fuel system has reached a presettable value, the valve 120 opens and the entry of the high-pressure pump 125 is acted on by a certain pressure. This pressure depends on the construction of the valve 120. Usually, the valve 120 is such that it frees the connection to the high-pressure pump 125 at a pressure of a few bar.

If the pressure in the low-pressure region rises to an impermissibly high value, the low-pressure limiting valve 140 opens and frees the connection between the exit of the pump 110 and the container 100. The pressure in the low-pressure region is kept at a value between about 1 and 3 bar by means of the valve 120 and the low-pressure limiting valve 140.

The arrangement of the low-pressure region, in particular the arrangement of the valves and filters, is illustrated only by way of example. The manner, the arrangement and/or the number of the elements can be different.

The high-pressure pump 125 conveys the fuel from the low-pressure region into the high-pressure region. The pump 125 builds up a very high pressure in the rail 130. Usually, a pressure value of about 30 to 100 bar is achieved in systems for an applied ignition engine and a pressure value of about 1000 to 2000 bar for a compression ignition engine. The fuel can be admetered by way of the injectors 131 under high pressure to the individual cylinders of the engine.

The pressure in the rail or in the entire high-pressure region is detected by means of the sensor 145. The pressure in the high-pressure region can be regulated by means of the pressure-regulating valve 135, which is controllable in drive by the coil 136. In dependence on the voltage lying across the coil 136 or current flowing through the coil 136, the pressure-regulating valve 135 opens at different pressure values.

Usually, a mechanical preliminary conveying pump is used as the pump 110. However, an electrical fuel pump with a direct current motor (DC motor) or an electrically commutated direct current motor (EC motor) can also be used. For higher conveyed quantities, required in the case of commercial motor vehicles, several parallelly connected preliminary conveying pumps can be used. In this case, EC motors are preferably used because of their higher service life and higher availability.

For regulation of the pressure P in the high-pressure region, further setting elements can be used alternatively and/or additionally, for example an electrical preliminary conveying pump adjustable in the conveyed quantity or a controllable high-pressure pump. In addition to the pressure-regulating valve 135, a pressure-limiting valve can also be provided, which at a preset pressure frees the connection between the high-pressure region and the low-pressure region.

The conveyed quantity QP is conveyed by the high-pressure pump 125 into the rail 130. A regulating quantity QDRV is discharged by way of the pressure-regulating valve 135 into the low-pressure region. A pressure build-up quantity QR is available for the pressure build-up. An admetered quantity QI is fed to the injectors 131 by way of the injectors 131. The quantity QI is composed of an injected fuel quantity QK, a leakage quantity and a control quantity of the injectors. The leakage quantity and the control quantity are fed back into the low-pressure region. The injected quantity of fuel is injected into the combustion chambers of the engine. The changes in quantity over a certain time span are denoted by Δ.

The regulation process is illustrated by the block diagram of Fig. 2. A control 200 presets a target value PS for the pressure in the storage device as well as a target value QDRVS for the regulating quantity. The target value PS for the pressure is applied with a positive

sign to a first input of an an interlinking point 205, at a second input of which the actual value P for the pressure is present with a negative sign.

A pressure regulator 210, which represents a first regulator, is acted on by the output signal of the interlinking point 205. The output signal ID of the regulator 210 is applied to a first setting element 135, preferably the pressure-regulating valve 135. The valve 135 determines the regulating quantity QDRV, which is conducted from the storage device 130 back into the low-pressure region.

The target value QDRVS for the regulating quantity is interlinked in an interlinking point 230 with the actual regulating quantity QDRV, which is applied with negative sign to the interlinking point 230. The output signal of this interlinking point 230 is applied to a second regulator 220, which represents a quantity regulator. The regulator 220 acts on a second setting element, in particular the admetering 122, by a drive control signal IN. The unit 122 influences the pump conveying flow QP.

The regulating path is denoted by 240. At an interlinking point 246, the pump conveying flow QP is reduced by the quantity QI conducted to the injectors 131. At an interlinking point 244, this quantity is reduced further by the regulating quantity QDRV. The remaining quantity QR, which is the pressure build-up quantity, serves for the build-up of pressure in the rail 130. In the case of the pressure build-up quantity QR, the rail 130 acts as an integrator, at the output of which the pressure P in the rail is present.

The first regulator 210 regulates the pressure in the storage device 130 to a target value. Starting from the deviation between the target value PS and the actual value P for the pressure, the first regulator 210 determines the drive control ID signal for action on the pressure-regulating means 135. This, independently of the drive control signal, discharges a regulating quantity from the storage device into the low-pressure region. This regulating quantity is regulated by the second regulator 220 to a target value.

In operation, the control 200 presets a target value for the desired pressure PS. This is compared in the interlinking point 205 with the actual pressure P, which is measured, for example, by means of the sensor 145. In dependence on this comparison, the pressure regulator 210 determines the drive control signal ID for the drive control of the first setting element 135. The pressure-regulating valve, by which the quantity conducted from the

high-pressure region back into the low-pressure region can be controlled, preferably functions as the first setting element.

By virtue of the feedback of the pressure, the pressure-regulating valve on its own represents a regulating loop. In the steady state, a pressure sets in, which is proportional to the current ID which flows through the coil of the pressure-regulating valve. In that case, the relationship applies:

$$\Delta QDRV = \Delta QP - \Delta QI.$$

In that case, ΔQP corresponds with the quantity conveyed by the pump per unit time and the magnitude ΔQI corresponds with the injected quantity per unit time. The quantity QK of fuel to be injected as well as the leakage quantity and the control quantity for the injectors thus participate in the admetered quantity ΔQI. The regulating quantity ΔQDRV, is the fuel quantity which is discharged into the low-pressure region by the pressure-regulating valve per unit of time.

Accordingly, the control presets the target value QDRVS for the regulating quantity in dependence on operating parameters. This is determined for the actual regulating quantity QDRV in the interlinking point 230 and fed to the quantity regulator 220. Starting from this regulating deviation, the regulator 220 determines the drive control signal IN for the second setting element, which is preferably the admetering unit 122. This unit operates in such a manner that it sets a pump conveying quantity QP proportional to the current IN. In place of the admetering unit 122, the preliminary conveying pump 110 or the high-pressure pump 125 can be controlled in drive in suitable manner.

A two-magnitude regulation takes place. The pressure P in the storage device 130 is regulated by the pressure-regulating valve 135 and the conveyed quantity QP by a setting element in the low-pressure region.

The presetting of the target value PS for the pressure takes place in dependence on different operating parameter magnitudes. These are, in particular, the injected quantity QK and the rotational speed N of the engine. The target value QDRVS for the regulated quantity is kept as low as possible subject to consideration of the driving power and the fuel heating. If a rapid pressure decay is desired, the target value is set to a high value.

The actual value QDRV can be measured by means of a quantity flow sensor which can be arranged between the pressure-regulating valve 135 and the container 100. Such a quantity flow sensor can, for example, be a differential pressure sensor. The use of an observer structure for ascertaining the actual value QDRV for the regulating quantity is particularly advantageous.

The regulating quantity QDRV is regulated to a target value which is just high enough for the pressure-regulating valve to operate in stable manner. The regulation takes place by way of a setting element in the low-pressure region, for example the admetering unit 122 or a controlled high-pressure pump 125.

The pressure-regulating valve 135 operates in unstable manner for small regulating quantities. In case of small regulating quantities, the pressure force is very small. This leads to a needle of the valve impacting on the valve seat and lifting off again immediately. Oscillations of this kind are to be avoided as far as possible. Accordingly, these oscillations are avoided by an increased regulating quantity.

Such an observer structure is illustrated in more detail in Fig. 3. Elements already described in Fig. 2 are provided with corresponding reference symbols. The actual observer is denoted by 300. The actual value P for the pressure as well as a signal ID, which characterises the current flowing through the pressure-regulating valve 135, is conducted to the observer 300.

The output signal of the observer 300 and the regulating deviation, which corresponds with the output signal of the interlinking point 205, are conducted to a quantity regulator 310. The output signal K of the regulator 310 is applied by way of an interlinking point 315 and an interlinking point 330 to the second setting element or admetering unit 122.

An output signal VI of a first preliminary control 320, which processes different operating parameter magnitudes such as temperature T and rotational speed N, is present at a second input of the interlinking point 315. An output signal V2 of a second preliminary control 335, which processes different operating parameter magnitudes such as injected fuel quantity QK and rotational speed N, is present at a second input of the interlinking point 330.

Two regulation targets are aimed at. The rail pressure is regulated with high dynamic range and high regulation quantity to a target value PS dependent on the operational state. This means that the target value is reached with a small regulating time and extremely small regulating deviation and transient duration.

The regulating quantity QDRV is regulated to a minimum least throughflow quantity. This takes place, in particular, for large injection and control quantities in steady engine operating states. This regulation target is achieved by a setting element arranged on the low-pressure side, preferably the admetering unit 122.

This second setting element 122 is in that case so controlled that the high-pressure pump 125 receives only so much fuel that the least required regulating quantity is at the disposal of the pressure-regulating valve 135 in the high-pressure circuit. This quantity is chosen so that the function of the pressure-regulating valve as setting element in the pressure-regulating circuit is ensured on the one hand and the service life of the valve seat in the pressure-regulating valve is ensured on the other hand.

The regulating loop for quantity regulation is such that the pressure-regulating valve is operated at its minimum throughflow quantity, for which purpose the actual regulating quantity QDRV does not have to be measured. The dependence of the regulating quantity QDRV, which flows through the pressure-regulating valve for a preset pressure P, is used.

The dependence of the regulating quantity QDRV on the current ID is illustrated in Fig. 4. In Fig. 4, the regulating quantity QDRV is entered as a function of the current ID. In that case, two characteristic curves for different pressures are illustrated. A curve for a low pressure is illustrated by a solid line and a curve for a high pressure is illustrated by a chain-dotted line. The minimum throughflow quantity, which is used as target value, is characterised by the dashed line QDRVS.

In the regulating range, a large change in the regulating quantity QDRV is associated with a small change in the electrical current ID, which in turn has the consequence of a large change in the pressure P. When the regulating quantity QDRV reaches the minimum throughflow quantity, the characteristic curve kinks over strongly. At this kink, the so-called minimum throughflow quantity QDRVS is reached, which the pressure-regulating

valve needs for faultless operation. For smaller regulating quantities, a small change in the regulating quantity QDRV is associated with a large change in the electrical current ID, which in turn results in small changes in the pressure P.

The second preliminary control 335 presets the drive control signal V2 for action on the second setting element 122 independently of the quantity QI to be fed to the injectors. This quantity is dependent on the quantity QK of fuel to be injected, the rotational speed and the control quantity of the injectors. The signal V2 is also preset in dependence on the desired change in the pressure and/or the change in the quantity of fuel to be injected. The value of the signal V2 acts as a preliminary control for the setting member 122.

The first preliminary control 300 takes into consideration the changes in the pump efficiency in dependence on the fuel temperature T as well as the drop in the pump efficiency with time. Equally, this preliminary control takes into consideration the leakage quantity at the injectors over the service life and as a function of the temperature. These magnitudes lead to a greater regulating quantity at the pressure-regulating valve over a wide range of the engine operation. The first preliminary control 320 presets the multiplication factor V1 by which the output signal of the quantity regulation 310 is multiplied at the interlinking point 315.

The two preliminary controls 320 and 335 preset such a drive control signal IN that a regulating quantity QDRV, which is greater than the minimum throughflow quantity, arises in all operational states. The quantity regulator 310 presets such a correction factor K for the drive control signal IN in the admetering unit 122 that the regulating quantity lies in the region of the minimum throughflow quantity or slightly thereabove. For this purpose, the regulator 310 evaluates the output signal of the observer 300.

If the regulator 310 recognises that a large regulating deviation is present, it issues a signal which counteracts the regulating deviation. It is thereby achieved that the target value is reached rapidly. This applies, in particular, when a rapid pressure decay is desired. In this case, the quantity regulator delivers such a signal that the regulating quantity becomes a maximum.

The co-operation of the first preliminary control 320, the quantity regulator 310 and of the observer 300 is illustrated as flow diagram in Fig. 5. If the equipment recognises in a step

500 that a steady operating state is present, the adaptation is activated. In unsteady operation, the factor VI of the first preliminary control is equal to 1. A steady operational state is recognised when the load and the rotational speed of the engine are constant and/or not more than one certain limit value changes. A magnitude characterising the quantity of fuel to be injected is used as load signal.

Subsequently, the instantaneous value P1 for the pressure P and the current I1 are filed in a step 510. The quantity regulator 310 then changes the factor K in a step 520 so that the regulating quantity QDRV becomes smaller by the value Δ. Subsequently, the new values for the pressure P2 and the current I2 are measured in a step 530. In a step 540, the differences dP and dI between the old values P1 and I1 as well as the respective new values P2 and I2 are determined. Starting from these values, the ratio dP/dI is computed in a step 550. An interrogation step 560 checks whether this ratio dP/dI is greater than a threshold value SW. If this is the case, i.e. the regulating quantity has been lowered so far that values below the minimum throughflow quantity QDRVS are reached, then the factor K is so changed in a step 580 that the regulating quantity QDRV is increased by the value Δ. On reaching the next steady operational state, a renewed program sequence takes place.

It is particularly advantageous if the factor K, on leaving the steady operational state, keeps the value QDRV constant.

If the interrogation step 560 recognises that the threshold value SW is not yet reached, the old values P1 and I1 are written over by the new values P2 and I2 in a step 570. Subsequently, a renewed program sequence takes place from the step 520.

The drive control signal for the setting element 122 is thus so changed in steady operational states that the regulating quantity is reduced. In that case, the change in the pressure P in dependence on the current I is observed. The drive control signal is varied until a large change in the current is necessary in order to vary the rail pressure. The quantity regulator 310 presets such a drive control signal for the second setting element 122 in steady operation that just the minimum throughflow quantity is discharged by the pressure-regulating valve into the low-pressure region.

Starting from the magnitude to be regulated, i.e. the pressure P and the setting magnitude, i.e. the current which flows through the first setting element 135, of the first regulating loop, the actual value of the second regulating loop is formed. The actual value of the second regulating loop has reached its target value when a large change in the setting magnitude has the consequence of only a small change in the magnitude to be regulated. The actual value of the second regulating loop has reached its target value when the behaviour of the first regulating loop changes significantly, i.e. when the relationship between the change in the current dI and the change in the pressure dP changes significantly.

In unsteady operational states, the quantity regulator 310 determines the drive control signal for the second setting element 122 in dependence on the difference between the target value PS and the actual value P for the pressure.

CLAIMS

1. A method of controlling an internal combustion engine, comprising the steps of conveying fuel by conveying means from a low-pressure region of a fuel supply installation of the engine to storage means for storing fuel to be supplied to the engine, setting the fuel pressure in the storage means by discharging a discharge quantity of fuel from the storage means into the low pressure region and regulating the discharge quantity in dependence on a target value.

2. A method as claimed in claim 1, wherein the fuel pressure in the storage means is set by a first regulator and the discharge quantity is regulated by a second regulator.

3. A method as claimed in claim 2, wherein the first regulator is operable to set the pressure in dependence on a target value for and a detected actual value of the pressure.

4. A method as claimed in claim 2 or claim 3, wherein the second regulator is arranged to act on at least one of a setting element in the low-pressure region and a high-pressure pump pumping fuel out of the low-pressure region.

5. A method as claimed in claim 4, wherein the second regulator is operable to drive the setting element in dependence on change in fuel pressure in the storage means and change in current flow through electrically operated regulating means regulating that pressure.

6. A method as claimed in claim 4 or claim 5, wherein the second regulator is operable to drive the setting element in dependence on the difference between a target value for and a detected actual value of that pressure.

7. A method as claimed in any one of claims 4 to 6, comprising the steps of controlling the setting element by at least one preliminary control value and of correcting the at least one preliminary control value by means of the second regulator.

8. A method as claimed in claim 7, wherein the at least one preliminary control value is determined in dependence on at least one operating parameter magnitude of the engine or of a vehicle fitted with the engine.

9. A method as claimed in claim 8, wherein the at least one operating parameter magnitude is engine speed or quantity of fuel to be supplied to the engine.

10. A method as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

11. Control means for controlling an internal combustion engine, comprising conveying means for conveying fuel from a low-pressure region of a fuel supply installation of the engine to storage means for storing fuel to be supplied to the engine, means for setting the fuel pressure in the storage means by discharging a discharge quantity of fuel from the storage means into the low pressure region and means for regulating the discharge quantity in dependence on a target value.

12. Control means substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

15

Application No: GB 9816006.2
Claims searched: All

Examiner: James Porter
Date of search: 16 September 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G3R (RBF)

Int Cl (Ed.6): F02D 41/30, 41/32, 41/38; G05D 16/20

Other: Online database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	EP0735268 A2 (ELASIS SISTEMA RICERCA FIAT) See whole document	1-3 & 11
X	EP0643219 A1 (MITSUBISHI) See whole document	1 & 11
X	WPI Abstract Accession No. 97-333890/199731 & DE19548278 A1 (BOSCH) 26.06.97 See Abstract, and discussion of this document on page 1 of the present application	1 & 11 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.